J. Glob. Innov. Agric. Soc. Sci., 2014, 2(3): 102-106.
ISSN (Online): 2311-3839; ISSN (Print): 2312-5225
DOI: 10.17957/JGIASS/2.3.561
http://www.jgiass.com

EFFECTS OF MULCHING AND FERTILIZER SOURCES ON GROWTH AND YIELD OF ONION

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Onion is an important horticultural vegetable in the urban Zimbabwe market. In Zimbabwe there is a need to improve the yield of onions on garden size areas utilizing locally available materials thereby avoiding purchased inputs which are often unavailable or inaccessible due to no supply or prohibitive price The present studies investigate the effect of trash grass and sawdust mulches in combination with organic and inorganic fertilizers on onion growth and yield. When the two mulching materials were compared, trash grass mulch favored the growth of onions more than sawdust mulch. Mulching improved soil water retention capacity, improved soil structure and suppressed weeds. These features played a significant role in the performance and ultimately the yield of onions. Similarly, total plant weight, aerial leaf weight, bulb weight and yields plot were also higher for samples taken from plots with trash grass mulch than those mulched with sawdust. This work also sought to evaluate mulching materials and fertilizer types on the various components of the onion plant at different stages of development and hence their contribution to the final yield. Trash grass in combination with organic and inorganic fertilizer the final yield improved by 160% and 310% respectively. As for sawdust, final yield improved by 103% and 275% for combinations with organic and inorganic fertilizer respectively. The effect of fertilizer types alone on the growth and yield of onions was less dramatic than that of mulch.
Keywords: Onion (*Allium cepa*), mulch, soil moisture content, weeds, yields

INTRODUCTION

Onion (*Allium cepa*) is an important horticultural vegetable in the urban Zimbabwe market. Out of 15 vegetables listed by FAO, onion falls second only to tomato in terms of total annual world production (Pathak, 2000). Commercial onion production ranges from 40-60 tons/Ha. According to FAOSTAT (2014) in Zimbabwe the average yield have been recorded as 4 tons/Ha which is quite low compared to figures recorded in the United States of 170 tons/Ha.

Onions are rather sensitive to drought stress (Zayton, 2007). One single most important factor that influences seed yield is soil moisture therefore, onions require frequent irrigations. The crop requires 350-500mm of water over the growing season (FAO, 2013) hence adequate moisture possibly through irrigation is important in the production of onions. Onion root system is shallow so it extracts very little water from depths beyond 60 cm.

Most of the water is from the top 30 cm of soil. Thus upper soil areas must be kept moist to stimulate root growth and provide adequate water for the plant. Mulching plays a significant role in the moisture conservation. In addition mulching suppresses weeds and maintains a narrow range of soil temperature. Thus, manipulation of the soil structure, soil moisture regime and fertilizer levels will enhance onion production.

Soil structure, soil water status during the growing period, soil fertility and weed infestation are general constrains of onion production. The significance of soil structure lies in the mechanical restriction of the soil to the bulb expansion (Grubben, 1994). Heavy soil will thus offer great mechanical restriction and bulbs will inevitably be smaller compared to those from light tilth soil. Under such soils, organic fertilizers complemented with mulch may improve the soil structure and hence onion yield. Currently in Zimbabwe there is a need to improve the yield of onions on garden size areas utilizing locally available materials thereby avoiding purchased inputs which are often unavailable or inaccessible due to no supply or prohibitive price. Black and white polythene mulch or organic mulch are a reasonable expense and conserve soil moisture (Mukherjee et al., 2004). Mulching with plant residues and synthetic materials is a well-established technique for increasing the profitability of many horticultural crops (Gimenez, et al., 2002). Such effects are mainly attributed to the capacity of mulch to conserve soil moisture (Vavrina and Roka, 2000). However, the objective of using mulches varies with the crop, the cropping system and the production environment. The most common objectives are to enhance crop growth by altering soil temperatures and conserving soil moisture (Lamont, 2005). Mulches may also control weeds and protect the crop from insect pests or disease (Ngouajio et al., 2008).

The objective of this study is to determine the effect of two mulch types (trash grass and sawdust) and two fertilizer types (organic and inorganic) on the growth and yield of onion under Mutare conditions.

MATERIALS AND METHOD

Description of the experimental site: The experiments were conducted at Africa University Farm (AU) in Mutare, Zimbabwe; located at 18° 53` S, 32° 36`E and 1104m asl. Average day length is 14 hours in summer to 11 hours in winter. Rainfall averages 800-1000 mm per year and temperature mean maximum are from 18 °C (July) to 32 °C (October). Hot summer is between September and December. The soil at AU farm is a red sandy clay loam, Fersiallitic 5E soil under Zimbabwe soil classification system (Nyamapfene, 1991).

Experimental design and treatments applied: Soil samples from experimental plots were analyzed for pH, Nitrogen, Phosphorus and Potassium levels to determine the rates of fertilizer treatments to be applied. The pH value was determined by Electrochemical Method; nitrogen levels by Macro-Kjeldah Method while phosphorus and potassium were determined by Bray and Kurtz No.1 method. A split-plot design was used with mulching (trash grass and sawdust) as the main plot treatments and the fertilizers as the sub-plot treatments.

To sufficiently cover the ground the mulching materials were applied at a rate of 3 kgm^{-2} for the trash grass and 3.5 kgm^{-2} sawdust. The application was done prior to transplanting so as to overcome the difficulties of applying grass mulch. An additional half the amount of these rates was applied each time of weeding in order to ensure complete coverage of the soil.

The rates of the fertilizer application were 3 kgm^{-2} for the compost and 18 gm^{-2} nitrogen in the form of Ammonium Sulphate, 10 gm^{-2} phosphorus in the form of Triple Superphosphate and 12 gm^{-2} potassium in the form of Potassium Sulphate.

Compost, phosphate and potassium fertilizers were applied at the time of transplanting as a basal dress while nitrogen was applied a week after transplanting as a top dress. Untreated plots represented the control for the main and sub-plot treatments.

Crop establishment and measurements: Seeds of Bombay Red were sown in unfertilized nursery beds on March 17, 2014.

Seven weeks later the seedlings were transplanted on to plot sizes of 2.8m x 3.5m on 0.3m high ridges. An in-row spacing of 12 cm was adopted. The plots were irrigated on four day interval at a rate of 9.5 mm using a watering can. Soil samples were taken (surface sampling) under each mulch treatment prior to irrigation to determine soil moisture content.

Variables measured: Data was recorded on; weed density, total plant weight (fresh), aerial leaf weight (fresh), bulb weight and bulb diameter. The experiment was terminated on August 30, 2014 when the plants had reached physiological maturity.

RESULTS

Weeds: Major weed species prior to setting up of the experiment were; Amaranthus spp, Bidens pilosa, Galinsoga parviflora, and Ecinochloa spp. However, after the experiment was established, Cyperus spp dominated the experimental plots.

Weed density: Mulching materials significantly (P 0.05) reduced weed density compared to the non-mulched plots (Figure 1). For the first three sampling dates, sawdust reduced weed density more than trash grass. However, at later dates, the two mulch types did not differ significantly in their depressing effect on weed growth.

Days to 50% maturity: Days to 50% maturity of onions grown under the two mulching materials were significantly more than those of onions grown under non-mulched conditions (Figure 2). However, the days to 50% maturity were not statistically different between both much treatments. Onions grown under zero mulch matured 2 weeks earlier than those grown under mulch.

Areal leaf weight: The effect of trash grass on the areal leaf weight was phenomenal, to the tune of nine fold of that from the control (Table 1). In non-mulched plots, only the organic fertilizer enhanced the growth of areal leaves significantly.

Soil moisture content: Mulching improves soil moisture conservation significantly (Table 2). At both soil depths, sawdust was numerically superior in water conservation than trash grass for the first three sampling dates.

However, soil moisture content was statistically significant in soil mulched with sawdust at both depths at the fourth sampling date. This result is in agreement with Marouelli et al., 2010 who observed that reduced moisture loss was due to the covered soil surface.

Bulb diameter: With both organic and inorganic fertilization treatments, mulching improved bulb diameter significantly compared to the non-mulch plots (**Table 3**). However, a combination of trash grass with any of three fertilization treatments, including the control, gave uniform onion diameter. Only trash grass enhanced bulb diameter significantly (P 0.05) when compared to those from the control.

The significant interaction of Mulch x Fertilizer on the diameter of the onion bulbs indicate the degree of influence of mulch and fertilization. The diameter of the onion bulbs was enhanced as a result of the interactions of mulch and fertilizer application.

Bulb weight: At final harvest, fertilizer type enhanced the weight of bulbs only in the mulched treatments. The trash grass mulch gave significantly heavier bulbs when in combination with organic and also with inorganic fertilizer. In plots with sawdust mulch, the weight of bulbs was only

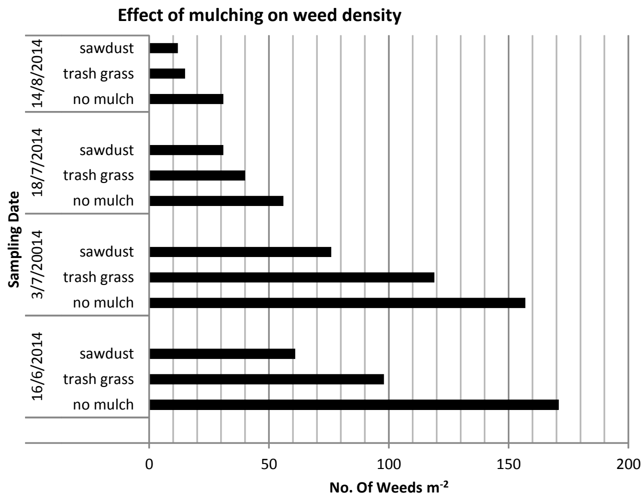

Fig. 1: Shows means of the effect of mulch on weed density at different growth stages in onion production.

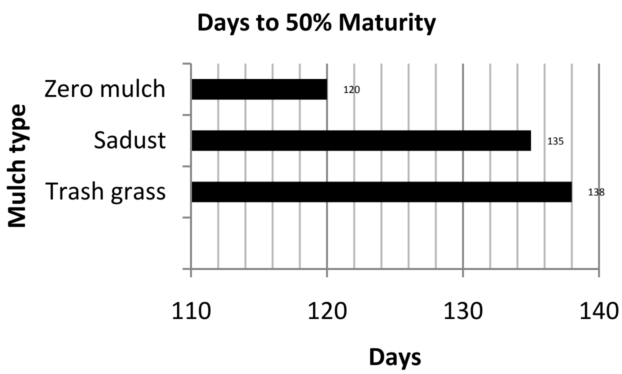

Fig. 2: Shows the means of days to 50% maturity from different mulching materials

Table 1: Shows the means of aerial leaf weight (g) of onions grown under different mulch materials and fertilizer type

	Fertilizer Type (F)			
Mulch type (M)	**F_{Zero}**	**$F_{Organic}$**	**$F_{Inorganic}$**	**$LSD_{(0.05)}$**
$M_{No\ Mulch}$	16.5^{aY}	26.8^{aZ}	15.3^{aY}	9.6
$M_{Trash\ Grass}$	145.6^{c}	135.9^{c}	129.5^{c}	NS
$M_{Sawdust}$	45.0^{b}	48.6^{b}	51.1^{b}	NS
$LSD_{(0.05)}$	4.7	6.7	23.4	
Mulch x fertilizer	NS			

significantly improved when in combination with inorganic fertilizer relative to the control (Table 4).

The degree of influence of mulch and fertilization was significant for the interaction of Mulch x Fertilizer on the weight of onion bulbs. The weight of the onion bulbs was favorably influenced by the interactions of the mulch and fertilizer.

Final yield: Application of fertilizer in combination of mulch improved yield of onions significantly. Similarly, with any fertilizer type, trash grass and sawdust mulches increased the yield markedly relative to the no mulch treatments (Table 5). Trash grass in combination with organic and inorganic fertilizer the yield improved by 160% and 310% respectively. As for sawdust yield improved by 103% and 275% for combinations with organic and inorganic fertilizer respectively.

These results are in agreement with Waterer (2010) who also observed an increase in yield for mulched plots relative to non-mulched plots. However, trash grass gave a higher yield than sawdust. The degree of influence of mulch and fertilization was significant for the interaction of Mulch x Fertilizer on the yield of onion bulbs. Mulching and fertilization positively improved the final yield of the onion bulbs.

DISCUSSION

When the two mulching materials were compared, trash grass mulch favored the growth of onions more than sawdust mulch. The total plant weight, aerial leaf weight, bulb weight and yields plot were higher for samples taken from plots with trash grass mulch than those mulched with sawdust. Anisuzzaman (2009) also observed taller plants which translate to more above ground biomass and final yield.

This may be due to better water conservation for plants under the mulch than trash grass and non-mulched plots. Mulching materials significantly reduced weed density. This could have been due to various physical factors especially preventing light from reaching the weeds underneath. This suggests that mulching should be tight so as to hinder photosynthesis by weeds under the materials and hence prevent further growth.

According to Mark (1999) organic mulches like hay and straw also add organic matter, but they do not always control weeds adequately. Mulch products had a significant effect on days to maturity compared to the control plots. However, between the mulched plots there was no effect noted. The effect to maturity days could be attributed to the influence of soil moisture since fertilization was only significant with mulch combinations. The insignificance different of mulch products in this experiment are in line with results by Miles et al., 2007 who noted that the effect of mulch products were generally not consistent. He also observed that, days to maturity of all crops investigated in 2007 were not significantly affected by mulch product. In contrast, Waterer (2010) in a similar trial with Zicchini, none of the mulch treatments altered the rate of development of the zucchini crop, as indicated by the time to 50% fruit yield relative to the non-mulched treatments. Anisuzzaman (2009) concluded that the longest time period was required for control treatment to reach 50% flowering as early flowering is an indicator of early maturity. Mulching improved the soil structure. The non-mulched plots were more compacted compared to the soils in the mulched plot. At harvesting it was very difficult to hand lift onion bulbs from the non-mulched plots and a garden fork had to be used to aid harvesting in these plots. Bulbs from mulched plots, especially those mulched with sawdust were easily hand lifted. Thus compaction might have restricted

Table 2: Shows the means of percent soil moisture content at two soil depths under different mulching materials

Mulch Type	16.06.2014		23.06.2014		28.06.2014		03.07.2014	
Sampling Depth (cm)	10	20	10	20	10	20	10	20
$M_{No\ Mulch}$	14.2^a	14.7^a	13.0^a	13.9^a	17.3^a	19.5^a	10.5^a	15.3^a
$M_{Sawdust}$	18.1^b	18.5^b	17.6^b	17.9^b	23.7^b	23.4^b	17.7^b	21.9^b
$M_{Trash\ Grass}$	17.5^b	18.0^b	16.9^b	16.5^b	21.6^b	22.0^b	10.6^a	15.6^a
$LSD_{(0.05)}$	1.7	1.7	2.6	1.7	1.4	2.4	0.8	0.6

Date Of Sampling

Table 3: Shows the means of diameter (cm) of onion bulbs grown under different mulch materials and fertilizer types (taken at harvesting date)

Mulch type (M)	F_{Zero}	$F_{Organic}$	$F_{Inorganic}$	$LSD_{(0.05)}$
	Fertilizer Type (F)			
$M_{No\ Mulch}$	5.0^{aY}	6.2^{aZ}	5.7^{aYZ}	0.6
$M_{Trash\ Grass}$	7.4^b	7.4^b	7.8^b	NS
$M_{Sawdust}$	7.1^{bY}	6.6^{aY}	8.1^{bZ}	0.6
$LSD_{(0.05)}$	0.8	0.7	0.4	
Mulch x fertilizer	0.5			

Table 4: Shows the means weight (g) of onion bulbs grown under different mulch materials and fertilizer types

Mulch Type (M)	F_{Zero}	$F_{Organic}$	$F_{Inorganic}$	$LSD_{(0.05)}$
	Fertilizer Type (F)			
$M_{No\ Mulch}$	58.8^a	61.8^a	61.3^a	NS
$M_{Trash\ Grass}$	117.1^{cY}	144.8^{cZ}	149.4^{cZ}	8.6
$M_{Sawdust}$	103.1^{bY}	110.1^{bY}	136.7^{bZ}	11.5
$LSD_{(0.05)}$	5.5	13.9	5.9	
Mulch x fertilizer	8.6			

Table 5: Shows the means of yield (kg/plot) of onion bulbs under different mulch materials and fertilizer types

Mulch type (M)	F_{Zero}	$F_{Organic}$	$F_{Inorganic}$	$LSD_{(0.05)}$
	Fertilizer Type (F)			
$M_{No\ Mulch}$	2.7^a	3.0^a	2.0^a	NS
$M_{Trash\ Grass}$	6.4^c	7.8^c	8.2^b	0.5
$M_{Sawdust}$	5.6^b	6.1^b	7.5^b	0.6
$LSD_{(0.05)}$	0.4	0.8	0.9	
Mulch x fertilizer	0.5			

expansion of the bulbs in the non-mulched plots and as a result the smaller onion bulbs compared to those from mulched plots. Subsurface compaction of soil significantly reduced onion yields. However, the depressive effect of sawdust mulch on the bulb weight could be attributed to various soil factors amongst which C/N ratio could be suggested.

It could possibly be that serious competition for available nitrogen results when residues have high C/N ratio (>30:1) are added to soils. Sawdust (C/N ratio is 500:1) would require and in fact make demands of nitrogen for its decomposition from the soil while trash grass made a similar demand but to a relatively modest extent.

It could possibly be that serious competition for available nitrogen results when residues have high C/N ratio (>30:1) are added to soils. Sawdust (C/N ratio is 500:1) would require and in fact make demands of nitrogen for its decomposition from the soil while trash grass made a similar demand but to a relatively modest extent. Furthermore, the organic fertilizer releases the required nutrients slowly over the entire growth period while the inorganic fertilizer is utilized faster and little of it lost through leaching. Hence a combination of sawdust and organic fertilizer would not seem to be a suitable combination for onion production. The effect of fertilizer types alone on the growth and yield of onions was less dramatic than that of mulch. This suggests that moisture and not type of fertilizer was the most important factor in performance of the onions. For any fertilizer type, the performance of the crop was better in the mulched plots for most of the parameters.

This has a very significant bearing in the production of onions. If mulch is available, yield of onions can be improved with application of organic fertilizer. It is important to know the responses of the various components of the plant to various inputs at the critical stages of growth. For example, a factor that will favor the development of aerial leaves is important because all food reserves originate from the processes of photosynthesis. Mulching enhanced the development of aerial leaves mainly at critical period of bulb growth. In the present study mulching improved the soil moisture content markedly through soil moisture retention at both soil depths. The water retention in mulched plots is due to effect of the soil coverage which works as a barrier preventing water evaporation from soil surface. According to Stone and Moreira (2000) the mulch cover initially acts in the soil-water evaporation process by reducing the daily evaporation rate due to higher solar radiation reflection, and consequently, the evapotranspiration. Non-mulched plots were exposed to the wind and direct sun heat thus most of the water was lost through evapotranspiration.

Hence the poor performance in these plots could have been as a result of limited uptake of nutrients by the roots from the soil. This could have had a negative effluence on canopy development (primary food producer through photosynthesis) and hence limited resources for the sinks (bulbs) which forms the harvestable yield. Pelter et al., 2004 also found out that if moisture is limited it reduces total yield. Soil moisture and weeds competition could be attributed to the significant different in yield between mulched and non-mulched plots.

CONCLUSION

The well known effect of mulch to suppress weeds is demonstrated by the results from this trial. Nevertheless, mulching materials varied in their effectiveness on onion productivity.

Although sawdust proved to be superior to trash grass mulch in soil moisture conservation and weed suppression,

the overall aspect of trash grass was to improve the yield of onions more than the sawdust mulch. Soil moisture levels was higher under mulches, which was known to allow rainwater to penetrate, yet reduce surface runoff as well as soil temperatures and evaporative losses.

The effect of fertilizer types on the performance of onions was better in the mulched plots than in the non-mulched plots. This has a very significant bearing in onion production. For an onion grower, if moisture is limiting no significant benefit will be realized from addition of any fertilizer type be it organic or inorganic unless mulching is practiced.

Therefore, it can be concluded from the present studies that trash grass plays a significant role in the production of onions particularly if it is complemented with fertilizer of any kind (organic or inorganic). Its role is attributed to its effect on the soil structure, moderate moisture conservation and suppression of weeds.

Soil moisture measurements may not fully reflect moisture conservation by mulches, because water consumption by the crop itself was not measured. Further research to this study could look into water consumption by the crop itself. Also to further investigate the effect of mulches on both physical and chemical properties of soil in onion production.

ACKNOWLEDGEMENTS

The authors thank all members of the Horticultural Department, Faculty of Agriculture and Natural Resource, Africa University for providing resources and devoting their time towards this project.

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